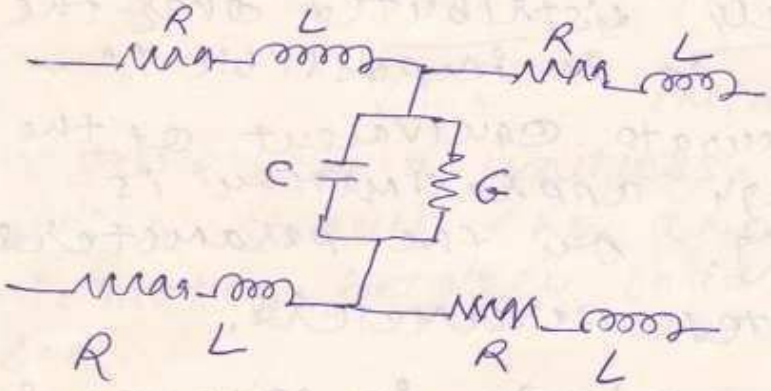
## * Transmission line:

- It is the media through which we can convey signal or power from source to destination

- Eq. circuit:




- At radio frequencies, appreciable radiation of energy may take place from the transmission lines.

- Possibility of radiation from a parallel wire line is prevented by keeping the separation between the two wires as low as $1/10^{th}$ of a wavelength.

- Because of current flow in the wires, a magnetic field is established around the line. The magnetic field links the wires and hence an inductance is said to be present.

- Even though there is no physical connection between the two wires the fact that input and output currents are different, suggest the possibility of an admittance between the wires.

→ This shunt admittance consists of a conductance and a capacitance in parallel.

→ The presence of capacitance is because the line consist of two conductors seperated by air-dielectric.

→ Since all the parameters of the line are uniformly distributed over the entire length, it is impossible to draw an accurate equivalent of the line. A rough approximation is shown in fig. But the parameters are distributed parameters.

→ **Characteristic impedance:**

It is the input impedance of an infinite transmission line.

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} \ \Omega$$

where

$R$ = Resistance / unit length ($\Omega/m$)

$L$ = Inductance / " " ($H/m$)

$G$ = conductance / " " ($\mho/m$)

$C$ = capacitance / " " ($F/m$)

→ For a lossless transmission line

$R = G = 0$, so $Z_0 = \sqrt{\frac{L}{C}} \ \Omega$

## * Standing wave Ratio (SWR)

→ It is the ratio of voltage maxima to voltage minima or current maxima to current minima of a standing wave pattern on a x'mission line.

$$SWR = \frac{V_{Max}}{V_{Min}} = \frac{I_{Max}}{I_{Min}}$$

→ SWR is a unitless quantity which shows the amount of mismatch between load & x'mission line.

→ It has values between

$$1 \leq SWR \leq \infty$$

→ If SWR is 1 load is perfectly matched with impedance of x'mission line. (Ideal value).

→ Higher the value of SWR, higher the mismatch.

## * Reflection co-efficient:

→ Ratio of reflected voltage to the incident voltage at the load end is known as ref. co-efficient ($\rho$)

$$\rho = \frac{V_{ref}}{V_{inci}} = \frac{I_{ref}}{I_{inci}}$$

→ It has values between

$0 \leq \rho \leq 1$.

→ For a matched load, $V_{ref} = 0$

$S^0$, $\rho = 0$

→ For an open or short load, $V_{ref} = V_{inci}$

$S^0$, $\rho = 1$.

→ Value of $\rho$ shows that how much amount of power is reflected back from the load. (Amount of mismatch).

* Relation between SWR & $\rho$ :

$$SWR = \frac{1+\rho}{1-\rho}$$

&

$$\rho = \frac{SWR - 1}{SWR + 1}$$

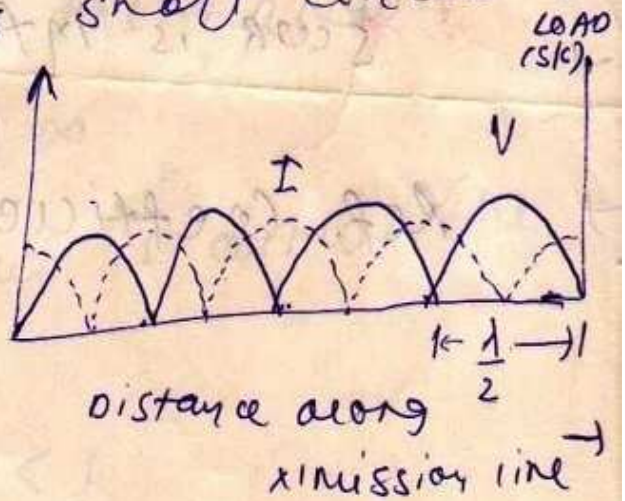
## * Standing wave pattern :

→ When there is mismatch between the load impedance & char. impedance of a X'mission line, microwaves are reflected back from load to source.

→ The combined pattern of forward and reflected waves is known as "standing wave pattern".

→ We have four diff. cases for values of SWR. for diff. types of loads.

① when load is short circuit :



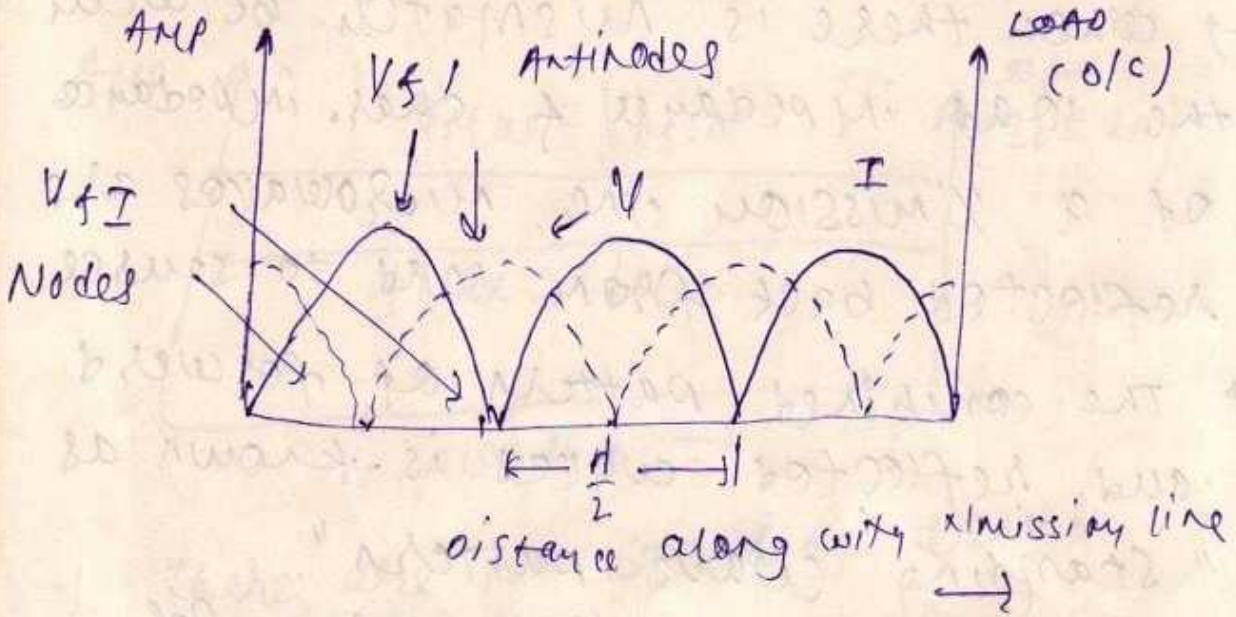

→ Voltage - minima

current - maxima

SWR = ∞

ρ = 1

(2) When the load is open circuit:



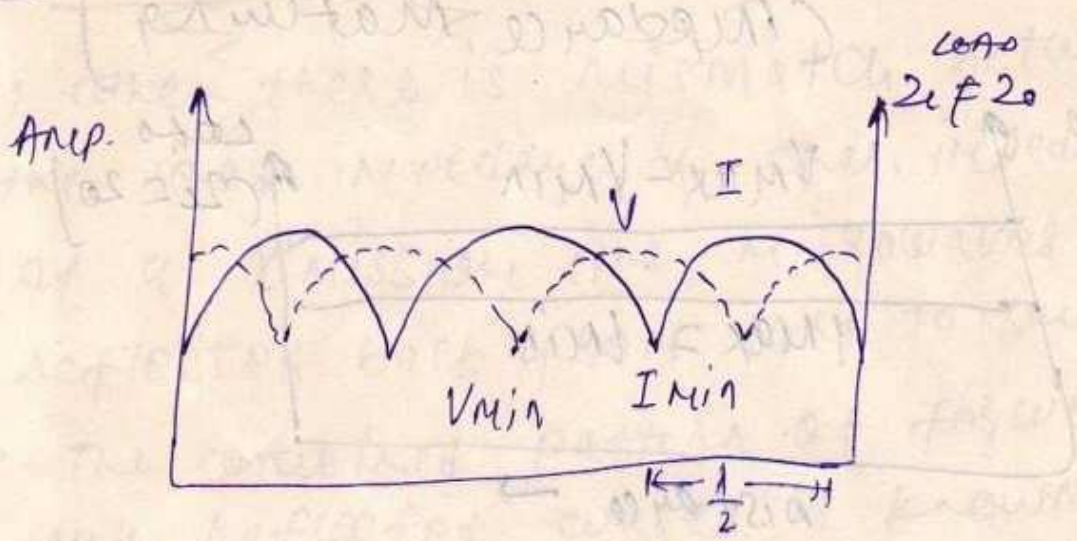

→ Current at minima

→ Voltage at maxima

→ SWR is infinite ∞.

→ Ref. Coefficient $\rho = 1$.

(3) when the load $Z_L \neq Z_0 \neq SC \neq OC$




→ position of current minima & voltage maxima depends on the type of load but they will be 0.

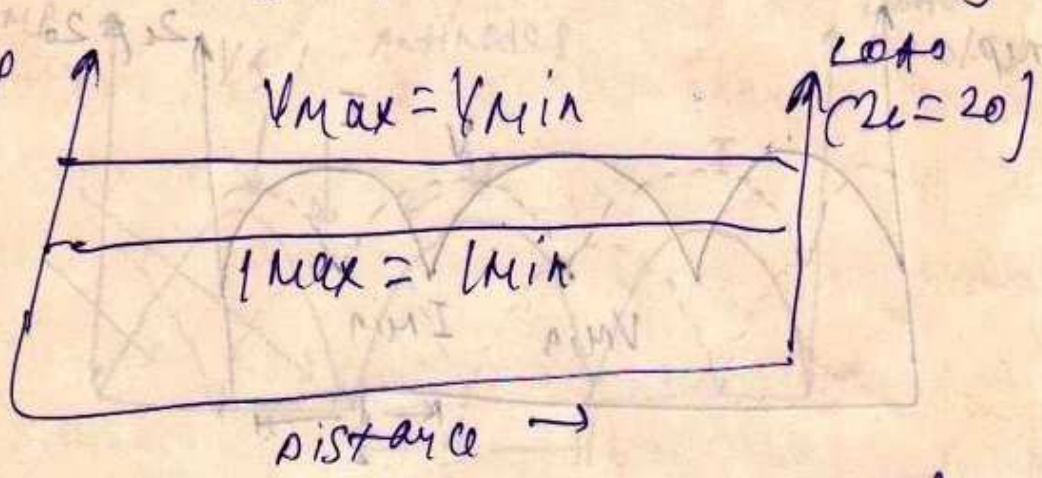
→ SWR is within the range

$$1 < SWR < \infty$$

→ Ref. co-efficient is within the range

$$0 < \rho < 1$$

(4) → when the load $Z_L = Z_0$
(Impedance Matching)




→ there are no standing waves.
(No minima or maxima)

→ Here $V_{max} = V_{min}$ & $I_{max} = I_{min}$

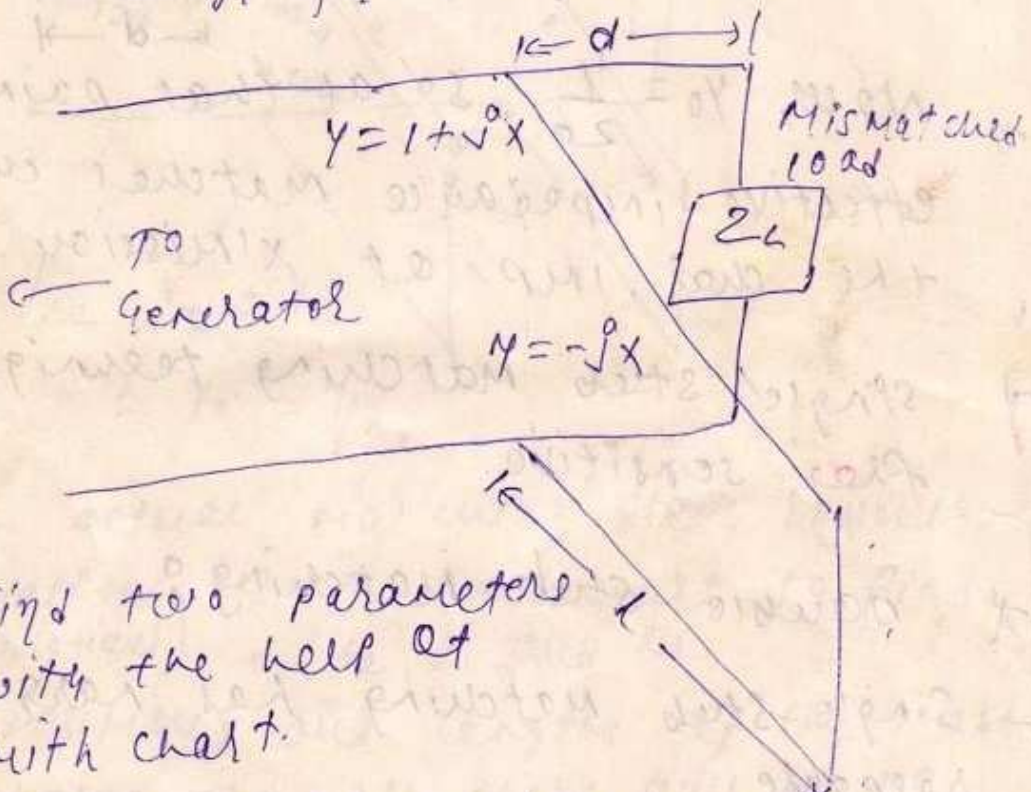
So, SWR = 1 (ideal condition)

→ And $\rho = 0$

* Single Stub Matching:

→ Stub is a piece of xmission line either open or short at its end.

→ Generally short ckt is preferred because open stub tends to radiate the energy from open ends.



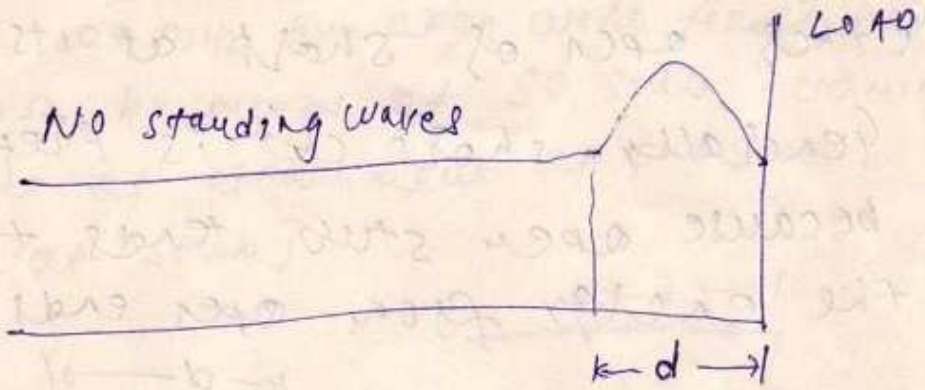

→ Find two parameters with the help of smith chart.

→ Distance to stub (d) & Stub length (l)

→ 'd' is so selected that admittance at the point where stub is to be connected becomes $Y_0 \pm jX$ ($Y_0 = 1/Z_0$)

→ 'l' is so selected that admittance at the point where the stub is to be connected cancels the reactive part of xmn. at xmission line

→ So, the resultant admittance at that point becomes $Y_0 + jx - jx = Y_0$




→ Now, $Y_0 = \frac{1}{Z_0}$, so at that point the effective impedance matches with the char. imp. of transmission line.

→ Single stub matching technique is freq. sensitive.

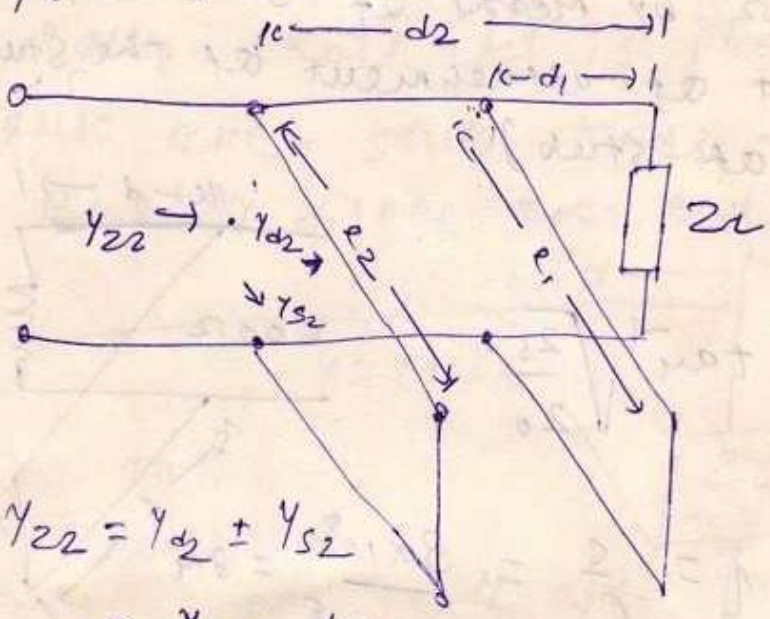
* Double stub matching :

→ Single stub matching has narrow band response

→ Some times it is impractical because stub can't be placed at ideal location

→ Hence, double stub is preferred to overcome the above deficiencies of single stub.

→ Double stub matching consist of two short-circuited stubs connected in parallel with a fixed length between like: $\lambda/8$, $3\lambda/8$ or $5\lambda/8$.




$$Y_{Z2} = Y_{d2} \pm Y_{S2}$$

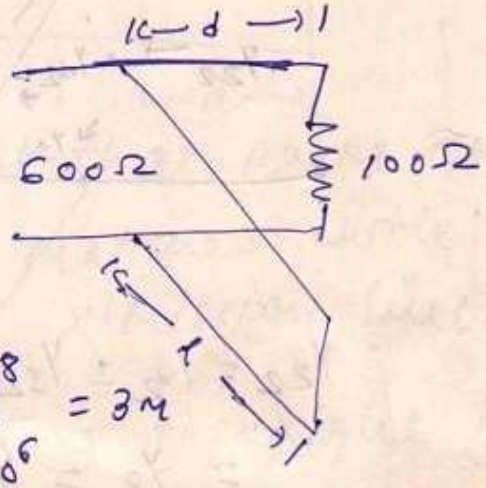
$$= Y_0 = 1/Z_0$$

→ The actual matching steps involve, Mathematical using smith chart to find (calculations) $d_1$, $d_2$, $l_1$ and $l_2$.

→ If positions and lengths of the stubs are chosen properly, there will be no standing waves on the line to the left of the second stub towards the source

→ By using double stub, FR (Bandwidth) of transmission line can be improved.

* A dipole antenna whose input imp. is pure resistance of 100Ω is matched at a freq. of 100 MHz by open wire feeder having $Z_0 = 600\Omega$ by means of SC stub. determine the point of attachment of the stub. (position of stub)




$$d = \frac{1}{2\pi} \tan^{-1} \sqrt{\frac{Z_s}{Z_0}}$$

Here $\lambda = \frac{c}{f} = \frac{3\times10^8}{100\times10^6} = 3m$

$Z_0 = 600\Omega$ & $Z_s = 100\Omega$

$$\therefore d = \frac{3}{2\pi} \tan^{-1} \sqrt{\frac{100}{600}}$$

$$= \frac{3}{2\pi} (22.2^\circ)$$

$$= \frac{3}{2\pi} \times 22.2 \times \frac{\pi}{180}$$

$$\boxed{d = 0.185\ m}$$

$R = 8\,\Omega/km, \quad L = 2\,mH/km$

$C = 0.002\,\mu F/km$

$G = 0.07\,\mu s/km$

$f = 2\,KHz$

$$Z_0 = \sqrt{\frac{Z}{Y}}$$

$$Z = R + j\omega L$$

$$\omega = 2\pi f$$

$$= 2 \times \frac{22}{7} \times 2000$$

$$\omega = 12571.43\ rad/sec$$

$$Z = 8 + j(12571.43)(2 \times 10^{-3})$$

$$= 8 + j\,25.14$$

$$= \sqrt{(8)^2 + (25.14)^2}\ \angle \tan^{-1}\left(\frac{25.14}{8}\right)$$

$$= 26.38 \angle 72.33^\circ$$

$$= 26.38 \times 72.33 \times \frac{\pi}{180}$$

$$=$$

$$\gamma = G + j\omega C$$

$$= 0.07 \times 10^{-6} + j(1257.43)(2 \times 10^{-9})$$

$$= 7 \times 10^{-8} + j(2514.28 \times 10^{-8})$$

$$= 10^{-8}(7 + j\,2514.28)$$

$$= 2514.28 \times 10^{-8} \angle 90^\circ$$

$$Z_0 = \sqrt{\frac{60.38 \angle 72.33}{2514.28 \times 10^{-8} \angle 90^\circ}}$$

$$= \sqrt{10^6 \angle -17.67}$$

$$Z_0 = 10^3 \angle -8.8^\circ \ \Omega$$